Development of an Smart Tool Holder for Online Error Monitoring in Single Point Diamond Turning

Liang An[1], Shiquan Liu[1], Yuan-Liu Chen[1,#]

1 The State Key Lab of Fluid Power and Mechatronic Systems, Zhejiang University, 310027, Hangzhou, China
Corresponding Author / Email: yuanliuchen@zju.edu.cn, TEL: +86-571-87952294 FAX: +86-571-87952294

KEYWORDS: Single-point diamond turning, Cutting force, Online error monitoring

The increasing demands for optical functional surfaces with complex micro-structures and high form precision push up the accuracy requirements of SPDT(Single Point Diamond Turning). Online error monitoring ensures the contin uity of the machining process, enabling efficient evaluation of machining quality and timely correction of machine tool drift errors, thereby playing an increasingly important role in manufacturing. However, the relatively harsh en vironment during the SPDT process, such as the blockage of chips, the extremely small processing area, severely limit the detection accuracy of conventional sensors like optical lenses and probes. In this work, a high-sensitivity, high-stiffness smart tool holder for three-axis cutting force measurement is developed based on a flexible hinge me chanism with symmetrically distributed piezoelectric sensors. A high-precision, low-cost detection solution for picoC oulomb-level weak charges is provided, achieving online detection of cutting forces with a resolution of 1mN. Base d on the smart tool holder, the mapping relationship between cutting force and the machined microstructure morp hology is studied, and real-time online error monitoring in SPDT microstructure machining is achieved. Experimen ts conducted on polymethyl methacrylate have confirmed the stability and accuracy of the online error monitoring smart tool holder, with measurement deviations less than 1.7% compared to advanced offline detection methods. T his method is of significant importance for achieving continuous high-consistency machining of large-area microstr uctured functional surfaces.